Research Article ISSN 2641-4295

Food Science & Nutrition Research

Effect of Plumpy'nut® on Malnourished Under Five Children in Kailahun, Eastern Sierra Leone

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Received: 28 Aug 2025; **Accepted:** 01 Oct 2025; **Published:** 12 Oct 2025

Citation: Victor Samuel Palmer, Mahmud Emkay Sesay, Kumba Yannah Karim Koroma, et al. Effect of Plumpy'nut® on Malnourished Under Five Children in Kailahun, Eastern Sierra Leone. Food Sci Nutr Res. 2025; 8(4): 1-8.

ABSTRACT

This study assessed the effect of Plumpy'nut® on malnourished under-five children and their comorbidities. Sixty malnourished under five children were selected from the Kailahun government hospital for the study. Data collected included patients' demography (age, height, weight and sex), nutritional status, clinical findings, breast feeding activities, co-morbid conditions, duration of admission, and treatment outcomes. The Multiple Linear Regression Models involving child's height, weight, mid upper arm circumference (MUAC) and amount of Plumpy'nut® given to the child were utilized to determine relationships among studied parameters. Findings revealed that majority of mothers did not practice appropriate exclusive breast feeding to their children (53%), the affected children were fed on rice (45.5%) and pap (34.1%); consequently, causing marasmus (72%), and kwashiorkor (20%). Majority of under five children admitted within November 2021 to June 2022 were males (57%), while 43% of them were females with a sex ratio of 1.3. About 68.8% of child's weight was explained by Plumpy'nut® during admission and after discharge. The most common diseases that infected under-five children at the time of admission at the hospital were diarrhea (35.2%), diarrhea and vomiting (21.6%), severe diarrhea (12.5%), vomiting (8.0%), cough (4.5%), cough and vomiting (3.4%) and dehydration (2.3%). A strong positive relationship (0.820) between amount of Plumpy'nut® given to the child after discharge and child's weight during nourishment that could be exploited as useful guide for policy makers in health program planning. Findings suggest use of awareness campaign, increased investment in health skill audits program, and quality health delivery services.

Keywords

Severe acute malnutrition, Paediatric, Under five infants, Outpatient therapeutic feeding program, Relationships, Plumpy′nut®.

Introduction

Malnutrition is an abnormal physiological condition caused by deficiencies, excesses or imbalances in energy, protein and/or other nutrients [1]. It is also referred to as "a state in which the physical function of an individual is impaired to the point where he/she can no longer maintain adequate bodily performance processes such as growth, pregnancy, lactation, physical work, and resisting and recovering from disease". Malnutrition is broadly categorized as moderate, acute, chronic or either as under-nutrition or over-nutrition [2,3].

Globally, it is estimated that approximately 60 million children suffer from moderate acute malnutrition (MAM) and 20 million from severe acute malnutrition (SAM). About 9% of sub-Saharan African and 15% of south Asian children have MAM, whereas about 2% of children in developing countries have SAM [4].

Majority of children affected with malnutrition are found in South Asia and Sub-Saharan Africa. Approximately 1-2 million children die annually from SAM as it is considered as the commonest reason for paediatric hospital admission in many poor countries. About 25-30% of children with severe malnutrition die during hospital admissions (WHO/UNICEF/WFP, 2007).

Malnutrition is an important risk factor with serious short- and long-term adverse effects on health such as stunting, increased morbidity and mortality from infectious and other disorders, and altered cognitive performance [5]. Children with SAM suffer from muscle wasting and reduced height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) z-scores below −3 SD [6]. The pathophysiology of SAM is not fully understood, but is associated with severe alterations of protein, glucose, and lipid metabolism, such as depletion of essential polyunsaturated fatty acids (PUFA) [7-9].

Sierra Leone is one of the countries with the highest maternal mortality rate around the world, and one of the highest mortality rates for children under five years old [10]. Out of 1,000 live births, over 13 mothers and 111 children under five die [11]. To address mortality issue and prevent death among under five children, the Centers for Disease Control and Prevention (CDC) helped establish the Child Health and Mortality Prevention Surveillance (CHAMPS) network in partnership with the Ministry of Health and Sanitation (MOHS) and the Bill and Melinda Gates Foundation. Malnutrition is widespread in the country, with 33 percent of children under-five years of age being stunted and approximately 176,269 suffering from acute malnutrition every year.

Out of 176,269, about 63,362 children are severely malnourished and at high risk of dying if left untreated [12]. Majority of these cases are found in the rural areas and urban slums were common heritage of poverty, ignorance, poor sanitation and other conditions contribute to the problems of malnutrition, interfere with its solution, and thus perpetuate the vicious cycle. The Sierra Leone Demographic and Health Survey [13] revealed that 36% of Sierra Leonean children are stunted, with 21% being severely stunted and stunting peaks at 48% among children aged 24-35 months. Moreover, 327,000 (34.1%) of Sierra Leonean children are stunted with 9.5% severely stunted, whilst 180,000 (18.7%) are underweight with 4.3% severely underweight.

Complementary foods are foods and liquids other than breast milk or infant formulas required during the second part of the first year of life for both nutritional and developmental reasons and to enable transition from milk feeding to family foods [14]. After 6 months of age, breast milk is not enough to meet the macro- and micronutrient requirements of infants [14,15]. Infants also develop the ability to chew; hence, begin showing interest for foods other than milk, therefore, there is the need to introduce healthy complementary foods [16]. According to the Codex Alimentarius Commission [10], complementary foods should be of appropriate nutritional quality and energy to complement the nutrients obtained from breast milk for infants and family foods for younger children. In Sierra Leone, examples of complimentary food are F100, F75, BP100, Plumpy′nut®, etc. Therefore, the need to assess the effect of Plumpy′nut® on malnourished children admitted in Kailahun Government Referral hospital.

United nations international children's emergency fund (UNICEF) has provided a life-saving basket of therapeutic foods that can be easily administered both at the therapeutic centres and homes to the most physically wasted under-five babies known as Plumpy′nut® [17]. These life-saving basket of therapeutic foods have been saving lives, restoring weight and health to millions of severely malnourished babies globally. However, little is known about the efficiency of the technique in solving the problem of severe acute malnutrition (SAM) among the under-five children admitted in Kailahun Government Referral Hospital, Eastern Sierra Leone. Moreover, since the introduction of the Plumpy′nut®, no comprehensive investigation has been done on its effectiveness in solving the problem of SAM in malnourished under-five children as well as identification of any diseases associated with the treatment of malnourished under-five children. Another problem is that the current existing facilities do not cover a large number of the under-five children suffering from malnutrition within the Kailahun district. Therefore, there is a need to assess the efficiency of life-saving basket of therapeutic foods such as Plumpy′nut® in solving the problem of severe acute malnutrition (SAM).

Several complementary foods have been developed in Sierra Leone but are mostly formulated with rice, cassava or maize as the major ingredient and complemented with cowpea, benni seeds and/or groundnut. These legumes are added to improve upon the fat and protein content of the food [16]. However, over the years the problem with malnutrition, especially undernutrition has led to the supplementation of complementary foods [18,19]. Amongst the world's most prevalent nutritional problems [20], Plumpy′nut® is among key complementary foods identified as a viable product for supplementing the nutritional needs of babies in developing countries. Malnutrition is prevalent among the very poor, particularly among women and under–five children. Likewise having a direct relationship on the high rates of infectious, other preventable diseases and infant mortality. Therefore, UNICEF steps in, with a life-saving basket of therapeutic foods that can be easily administered both at home and hospital to the most physically wasted babies. As a result of this, there is a need to assess the effect of Plumpy′nut® on malnourished under-five children. Thus, the aim of this study was to determine the effect of Plumpy′nut® on malnourished under-five children and their comorbidities been admitted into Kailahun government hospital from November 2021 to June 2022.

Methodology

Study area, Study design and Population

This study was carried out at the inpatient facility of Kailahun District Government Referral Hospital, which is the only referral hospital in the eastern province of Sierra Leone.

The experiment involved daily measurement of weight, height,

mid upper arm circumference and quantity of Plumpy′nut® given to all malnourished under-five children upon day of admission up to discharged date and home follow up at the inpatient facility of Kailahun District referral hospital from November 2021 to June 2022.

The study population included all malnourished under-five children (60 patients) that reported, and were diagnosed, admitted, treated, died and discharged at the inpatient facility of Kailahun District referral hospital from November 2021 to June 2022.

Data collection procedure, quality control, data handling and analysis

Patients demography (age, height, weight and sex), nutritional status, clinical findings, breast feeding activities, co-morbid conditions, duration of admission, treatment outcomes were recorded after measuring the patients. The data collected were double checked to minimize data entry errors. Data cleaning and analysis were carried out using Statistical Package for Social Sciences (SPSS) version 16. The findings were presented in tables, graphs and charts (like bar charts, pie charts, etc.).

The multiple linear regression analysis was done for determination of relationships among nutritional status, clinical findings, breast feeding activities, co-morbid conditions, duration of admission, treatment outcomes using various multiple linear regression equation models used are given below.

Multiple linear regression model 1

$$W = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \mu$$

…… eqn. 1

Where: $W = Child's\ weight\ during\ nourishment;$
$X_1 = Amount\ of\ pupmpy\ nut\ child\ fed\ on\ during\ admissio$
$X_2 = Amount\ of\ pumpy\ nut\ child\ feed\ on\ after\ admission$
$\beta_{0\ =Intercept\ coefficient};\ \ \beta_1 = Slope\ of\ X_1;\ \ \beta_2 = Slope\ of\ X_2;$
$\mu = Disturbance/error\ \ term$

Hypotheses: Hypothesis 1

$\boldsymbol{H_0 = 0}$: There is no linear relationship between amount of Plumpy′nut® fed by under five children during admission and their weight.

$\boldsymbol{H_1 \neq 0}$: There is linear relationship between amount of Plumpy′nut® fed on during admission and their weight.

Hypothesis 2

$\boldsymbol{H_0 = 0}$: There is no linear relationship between amounts of Plumpy′nut® child feed on after admission and the weight of the child.

$\boldsymbol{H_1 \neq 0}$: There is linear relationship between amounts of Plumpy′nut® child feed on after discharge and the weight of the child.

Multiple linear regression model 2

$$H = \beta_3 + \beta_4 X_3 + \beta_5 X_4 + \mu_2$$

…… eqn. 2

Where: $H = Child's\ height\ during\ nourishment$

Hypothesis 3

$\boldsymbol{H_0 = 0}$: There is no linear relationship between amount of Plumpy′nut® child fed on during admission and the height of the child.

$\boldsymbol{H_1 \neq 0}$: There is linear relationship between amount of Plumpy′nut® child fed on during admission and the height of the child.

Hypothesis 4

$\boldsymbol{H_0 = 0}$: There is no linear relationship between amounts of Plumpy′nut® child fed on after admission and the weight of the child

$\boldsymbol{H_1 \neq 0}$: There is linear relationship between amounts of Plumpy′nut® child feed on after discharge and the weight of the child

Multiple linear regression model 3

$$MUAC = \beta_6 + \beta_7 X_5 + \beta_8 X_6 + \mu_3$$

……..…… eqn. 3

Where:
$MUAC = Child's\ MUAC\ during\ nourishment$
$X_5 = Amount\ of\ Plumpy'nut®\ child\ fed\ on\ during\ admission$
$X_6 = Amount\ of\ Plumpy'nut®\ \ child\ feed\ on\ after\ admission$
$\beta_6 = intercept\ coefficient$
$\beta_7 = Slope\ of\ X_5$
$\beta_8 = Slope\ of\ X_6$
$\mu_3 = Disturbance/error\ \ term$

Hypothesis 5

$\boldsymbol{H_0 = 0}$: There is no linear relationship between amount of Plumpy′nut® child feed on during admission and MUAC of the child

$\boldsymbol{H_1 \neq 0}$: There is linear relationship between amount of Plumpy′nut® child feed on during admission and MUAC of the child.

Hypothesis 6

$\boldsymbol{H_0 = 0}$: There is no linear relationship between amounts of Plumpy′nut® child feed on after admission and MUAC of the child.

$\boldsymbol{H_1 \neq 0}$: There is linear relationship between amounts of Plumpy′nut® child feed on after discharge and the MUAC of the child.

Results

Ages of under-five children admitted for malnutrition

Majority (43.59%) of the under five children admitted were between 11-20 months old, followed by 0-10 months old (32.05%) and 21-30 months old (19.23%), while the lowest number of then were between 41-60 months old (Figure 1). These findings indicate that higher numbers of tender aged infants were the most affected by malnutrition. The results imply that poor practice of exclusive breast feeding, giving early complementary feeding, poor hygiene or sanitation practice may have contributed to malnutrition in the

tender aged infants.

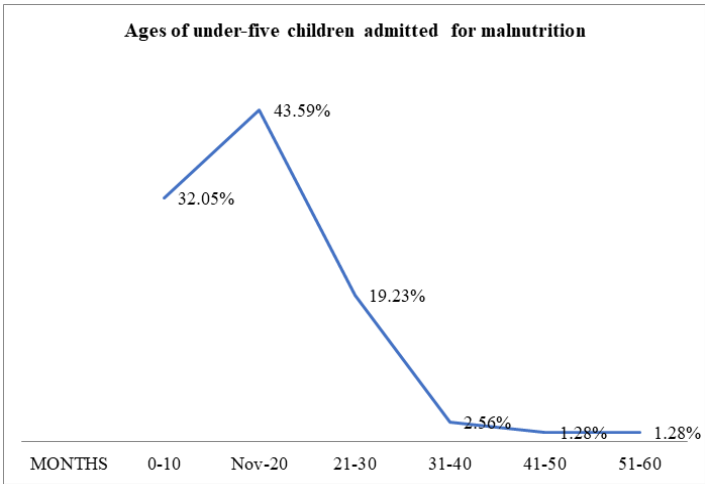

Figure 1: Age categories of under-five children admitted for malnutrition. Source: Inpatient Data 2022.

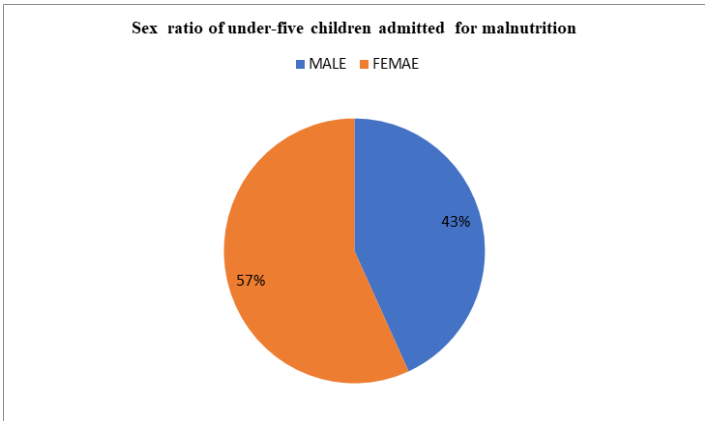

Figure 2: Sex ratio of under-five children admitted for malnutrition. Source: Inpatient Data 2022.

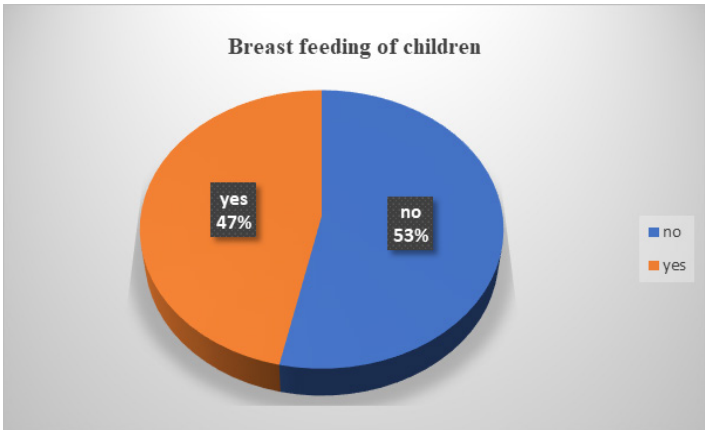

Figure 3: Breast feeding of malnourish children under age five. Source: Inpatient Data 2022.

Breast Feeding of Under-five Children Admitted for Malnutrition

Majority of women whose under-five children were admitted did not practice appropriate exclusive breast feeding to their children (53%), while 47% of practiced appropriate exclusive breast feeding to their children (Figure 3). This implies that majority of the mothers neglected the practice of appropriate exclusive breast feeding to their children needed for their improved early growth possibly due to the fact that some of the care-givers were traders and school girls. As such, they live their children with their relatives and grandmothers who introduce them to early complimentary feeding.

Diseases caused by malnutrition in under-five children admitted at the Kailahun government referral hospital

The Pie Chart shows that most of the children were affected by marasmus (72%), followed by kwashiorkor (20%), while severe malaria and marasmus accounted for 5%, and the remaining including marasmus with oedema, anaemia and marasmus, and severe anaemia, accounted for 1% each (Figure 4). Findings indicate the various comorbidity diseases that affect under five children before admission. It implies the relevance of the generated knowledge in contributing to improve management of SAM thereby reducing the associated burden of disease.

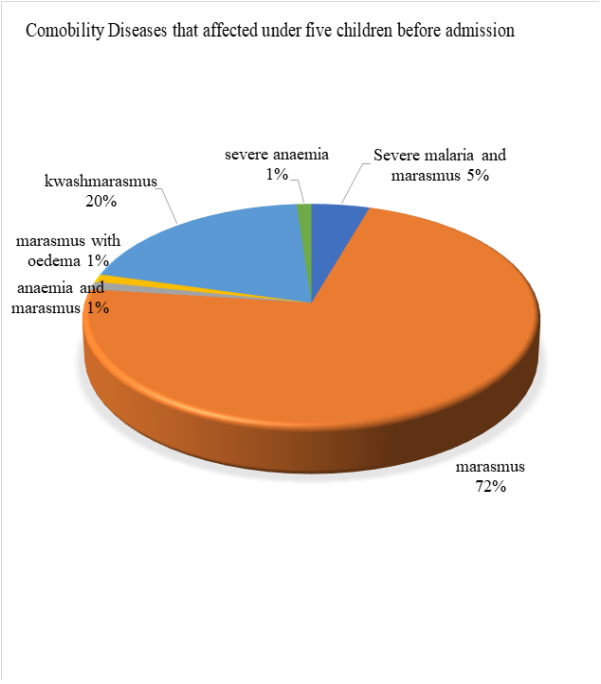

Figure 4: Comorbidity diseases that affected under five children before admission. Source: Inpatient Data 2022.

The Bar chart in Figure 5 indicates that majority of the malnourished under five-children were fed on rice (45.5%) and the next common meal was pap (34.1%). Under five-children who feed on family food (meal) accounted for 10.2%, corn pap (1.5%) and the least type of food taken was Nutrilac (1.1%).

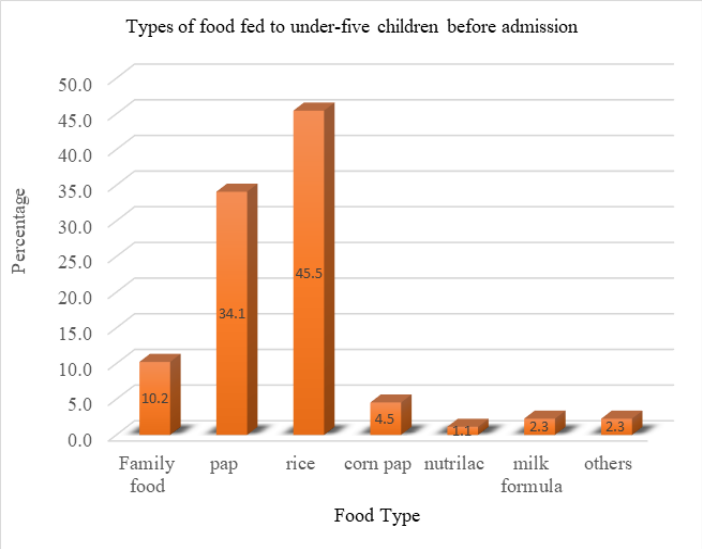

Figure 5: Shows types of food fed to under-five children before admitted during the study period. Source: Inpatient Data 2022.

Figure 6 presents diseases affecting under-five children during admission period while fed on Plumpy′nut®. The most common disease that infected under-five children at the time of admission at the hospital and during treatment using Plumpy′nut® was diarrhea (35.2%), followed by diarrhea and vomiting (21.6%), severe diarrhea (12.5%), vomiting (8.0%), cough (4.5%), cough and vomiting (3.4%) and dehydration (2.3%).

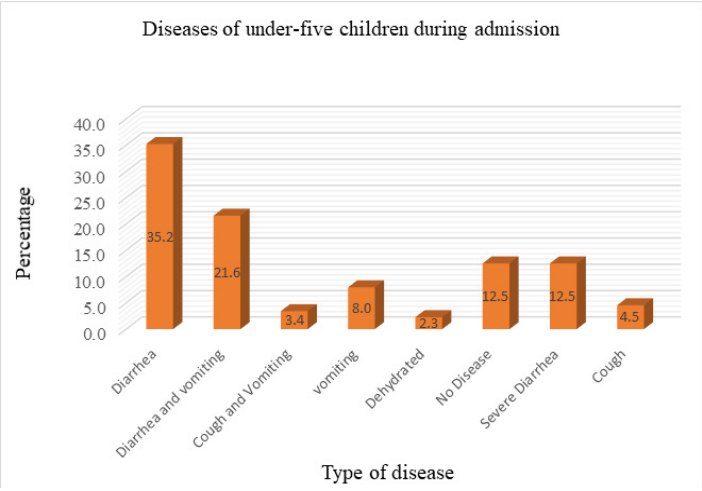

Figure 6: Diseases affecting under-five children during admission period while fed on Plumpy′nut®. Source: Inpatient Data 2022.

Effects of nourishment feeding on body weight, height and upper arm circumference

The multiple regression model 1 reveals that the mean weight of children during nourishment feeding is 6.820827 kg; mean amount of Plumpy′nut® given to child during admission is 30.1176 sachets; and after discharge is 18.4353 sachets.

Findings on the Pearson correlation coefficients show an inverse weak relationship (-0.206) between weight of child during nourishment feeding and amount of Plumpy′nut® given to child during admission; but strong positive relationship (0.820) between amount of Plumpy′nut® given to the child after discharge and child's weight during nourishment. The test result shows that both periods, during and after discharge Plumpy′nut® is statistically significant to child's weight (during admission, p = 0.030, and after discharge p = 0.0001) to child's weight.

The model summary gives the coefficient of determination. This value determines how much the independent variables (Plumpy′nut® during admission and after discharge) can account for weight of the child. The coefficient of determination (R-square) is 0.688 i.e. 68.8%, indicating a good model fit. This means that 68.8% of child's weight was explained by Plumpy nut during admission and after discharge.

The analysis of variance (ANOVA) shows that the overall model is statistically significant (p = 0.0001). The model should therefore be accepted. The contribution of individual independent variables in the determination of child's weight reveals that Plumpy′nut® feeding during admission is statistically significant (p = 0.013), and Plumpy′nut® feeding after discharge is also statistically significant (p = 0.0001). This means that in both hypotheses we reject the null hypothesis at 5% level of significance, and conclude that Plumpy′nut® feeding during admission and after discharge are important for child's weight.

The model is now written as:

$$W = 1.72 - 0.018X_1 + 0.306X_2$$ .....eqn. 1

The model depicts that Plumpy′nut® feeding after discharge contributes more to child weight (0.306) than during admission (0.018). With one unit (sachet) increase in Plumpy′nut®, child's weight would increase by 0.306 kg (directly proportional), holding other variables constant. In the case of Plumpy′nut® given to child during admission, has negative (inverse) relationship with child's weight; and keeping other variables unchanged, with one sachet reduction, weight will increase by 0.018 kg.

The results on regression model 2 is similar to model 1 in that the mean for amount of Plumpy′nut® given to child during and after discharge remains the same based on descriptive statistics. The mean height of children is 72.23 cm. The Pearson correlation coefficient indicates a weak inverse relationship between height of child during admission, and amount of Plumpy′nut® fed on (-0.103); and a strong direct (positive) relationship after discharged (0.838). The height after discharge in relation to amount of Plumpy′nut® the child eats is statistically significant (p = 0.0001) but statistically insignificant during admission (p = 0.173). The model summary result shows that the regression model is a good fit since R-square is 0.705 (70.5%). This means that the independent variables (Plumpy` nut during and after discharge) explained 70.5% of the variation observed in the height of the children. The coefficient the

regression shows that Plumpy′nut® during admission is inversely related to height and statistically insignificant (p = 0.401), and with one-unit increase in Plumpy′nut®, the height would increase by 0.032 cm. On the other hand, the height of child is directly related to amount of Plumpy′nut® child feed on after discharged. The result shows statistically significant (p = 0.0001). And keeping other factors constant, with one sachet Plumpy′nut®, height would increase by 1.685 cm. The null hypothesis is therefore rejected at 5% level of significant (Hypothesis 3), while the null hypothesis is retained in Hypothesis 4. It is therefore concluded that Plumpy′nut® given to a child after discharge contributes directly to the child's developmental height.

The regression model is given below:

$$H = 42.136 - 0.032X_3 + 1{,}685X_4$$

……..…eqn. 2

Model 3 depicts the relationship between child's MUAC and Plumpy′nut® feeding during admission and after discharged. The model shows similar result as in model 2. Weak inverse relationship exists between child MUAC and Plumpy′nut® feeding during admission (-0.008); and weak direct relationship with amount of Plumpy′nut® after child has been discharged.

The Pearson Chi-square test of effect of type of food child feeds on versus body condition of the child was statistically significant (p = 0.0001). The effect of type of food child feeds on versus body condition of the child is moderate (Cramer's v =0.408). The effect of breast feeding of child on body condition shows small effect (Cramer's v =0.272) and it is not statistically significant (p = 0.368).

Discussion

Malnutrition results from eating a diet in which nutrients are insufficient or are in excess supply such that it causes health problems. This study assessed the response of malnourished children to the ready-to-use therapeutic foods (RUTFs) "plumpy nuts'' which contains calories and essential nutrients that restore and maintain body weight and health in severely malnourished children. Findings reveal that the ages of under-five children influence their vulnerability to malnutrition. In the present study, higher numbers of tender aged infants were the most affected by malnutrition implying that poor practice of exclusive breast feeding, giving early complementary feeding, poor hygiene or sanitation practice may have contributed to malnutrition in the tender aged infants.

The sex ratio of under-five children admitted for malnutrition during the study period shows that majority of the malnourished children were male, with a ratio of 1.3 implying that boys are more likely to be undernourished than girls. Findings suggest a significant gender disparity in malnutrition among this age group studied. These findings are consistent with those of Diakité, et al. [21] and Kngaye, et al. who reported ratio of 1.3.

Breast feeding is a critical practice for prevention of malnutrition in under-five children. Findings of this study revealed that majority of women whose under-five children were admitted did not practice appropriate exclusive breast feeding to their children (53%) indicating that majority of the mothers neglected the practice of appropriate exclusive breast feeding to their children needed for their improved early growth possibly due to the fact that some of the care-givers were traders and school girls. As such, they often live their children with their relatives and grandmothers who introduce them to early complimentary feeding. This attitude flouts the WHO and UNICEF recommendation of giving under-fives nutritionally-adequate and safe complementary (solid) foods at six months of age alongside continued breastfeeding up to at least two years.

Malnutrition in under-five children contributes to poor health outcomes. In this study, various comorbidity diseases notably affected under-five children before admission. These findings imply the relevance of the generated knowledge in contributing to improve management of SAM thereby reducing the associated burden of disease. Findings agree with the view that information derived from health study serves as useful guide for policy makers in health program planning [22,23].

The poor infant and young child feeding (IYCF) practices by caregivers could have probably caused the alarming rate of malnutrition in the under five-children studied leading to high burden of environmental-related communicable diseases. These findings are in support of Rapson, et al. [24] who opined that high food insecurity, poor infant and young child feeding (IYCF) practices, poor maternal health and nutrition, high burden of environmental-related communicable diseases and inadequate access to quality essential health services and poor access to sanitation and hygiene contribute to malnutrition. The carbohydrate-based dietary formulation mainly on maize, cassava, or rice have been opined to be frequently associated with the kwashiorkor disease [25]. Findings also support the view that caregivers' understanding of the links between health, diet, and physical activity in children are critically important in strategizing to eliminate childhood undernourishment or obesity [26,27].

In therapeutic feeding programs (TFP), mid-upper arm circumference (MUAC) shows advantages over weight-for-height Z score (WHZ) and is recommended by the World Health Organization (WHO) as an independent criterion for screening children 6–59 months old. The findings on nourishment feeding on body weight, height and upper arm circumference reveal that the coefficient of determination (R-square) is 0.688 i.e. 68.8%, indicating a good model fit. This means that 68.8% of child's weight is been explained by Plumpy nut during admission and after discharge.

There were some possible limitations to the study. Due to limited funding for the student research, the scope of the study was narrowed to the referral hospital in Kailahun. However, future studies would consider lots of communities and additional

parameters on new emerging issues.

Conclusions

This study has demonstrated that higher numbers of tender aged infants (0-30 months old) were the most affected by malnutrition. The majority of the lactating mothers neglect the practice of appropriate exclusive breast feeding of their children leading to malnutrition diseases such as marasmus, kwashiorkor and other diseases could be exploited as a serious entry point for increased sensitization and provision of improved health delivery and monitory system.

Findings of this study suggest that: (i) the need to create or increase awareness about the consequences and implications of malnutrition in under five children and promote strategies to prevent and control them; (ii) To ameliorate the consequences and implications of malnutrition, improved nutritional knowledge could be targeted at improving health status of infants by introducing them to complimentary foods and practice of appropriate exclusive breast feeding. However, future interventions and planning in improved nutrition should strongly feature more infants; (iii) the need for increased health challenge interventions on the agenda of the ministry of health and sanitation, health research institutions and health universities so that community health officers and nurses are adequately trained and equipped to enable them to assist malnourished under-five children; and (iv) that government should increase investment in health skill audits program, provide quality health delivery services as well as increase the number of existing health facilities for treatment of malnourished under-five children.

Acknowledgements

We thank the teams of intensive care units as well as the specialized specialists, who were directly involved in the diagnostics and treatment of the patients at the Kailahun Government Referral Hospital. We thank the center management for their support and participation in the collection and collating of data utilized in this study.

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